is depending on 100 per cent. of good judgment and good conscience and 99 per cent. of good luck, when it is his duty to calculate on a minimum of these elements. He must allow for a low percentage of judgment and conscience and not depend on luck at all. In one aspect of the case the application by Congress of 16-hour law penalties to the employer and not to the employee is rational; for the employee's misconduct in many cases—such as going to a circus or a ball game when he ought to be asleep at home—cannot be made subject to rigid rules (except such as the man himself can establish in his own mind); whereas the officer, being unable to deal with the engineman's conscience and his personal habits when off duty, must of necessity work by a rule, even if it be an extravagant or troublesome rule.

CONTINUOUS RAILS FOR UNIFORM TRACK STRUCTURE.

The function of the rail in the track is to guide the wheels and to distribute the loads to the ties. The ties in turn distribute the loads to the ballast, and the ballast to the subgrade. This applies to lateral thrust as well as to vertical loads. These three distributors should be considered, each entirely separate from the other, and they should each be made to distribute the loads equally at all points along the track in order to have ideal conditions. Bad results come from expecting the ties or rail to bridge over a soft spot where the ballast is not performing its work uniformly, or from expecting the ties to do some of the work of a rail-joint that is not as stiff as the rail. If one of these distributing agents is required to do some of the work of another in addition to its own, at any one point in the track more than at another, then this one point is surely a weak one in the structure.

It is quite practicable to make the ballast conditions along the track almost uniform. The ties in themselves, of course, can be about the same, but in the rail structure, the joining of one rail to another seems to preclude uniformity, and it is very difficult to obtain in this structure exactly the same conditions throughout. Ideal conditions would be attained by a continuous unbroken rail, which would have no joints and would perform its function the same at every tie. This seems then to resolve the task into a problem of uniform splicing of the rails without any reference to the ties, rather than the solving of the long mooted questions, as to whether the joint should be of the suspended or supported type; whether one, two or three ties should help support the joint, or whether the ties should be considered as a permanent abutment for a bridge. If the rail structure throughout its length were in itself uniform in lateral and vertical stiffness, in its bearing on the ties, in its spiking facilities, etc., then all these other considerations of the tie in connection with the splice would be eliminated, and the ties could be placed wherever a good uniform spacing would bring them, as far as the assistance they render to the splicing of the rails is concerned. Railroads would then no longer be spending so much money renewing battered, bent and broken rail ends, or persistently driving ballast under the joint ties as fast as it disappears into the ground. All this trouble seems to be caused by periodic weak and otherwise uniform places in the jointed rail-structure. It is the lack of stiffness in the upper structure that permits the excessive deflecting of the ties, rather than the lack of bearing under the ties that permits the excessive deflection of the rail. This is precisely similar to the lateral conditions in which a lack of stiffness at the joints makes good alinement difficult.

Much of the present research and ingenuity seems to be exerted along wrong lines; all, perhaps, because in these considerations many people have been unwilling to isolate the ties from the joints, and persist in asking one to do part of the work of the other. The isolated splicing of the rails seems to be the fundamental problem, and the correct solution of it should be more generally accepted in the present efforts to strengthen track. With this problem solved, lighter rails would afford as good service as is now obtained with the large rail sections: not that the use of lighter rails is proposed, but what is equal to the same thing, the efficiency and strength of the present track could be greatly increased.

This analysis may seem theoretical and the task impracticable on account of being beset with so many difficulties. It is necessary, then, to look at these difficulties and to consider from the practical side what the conditions are, and what must be met in joining two isolated rails so that they will act like one when laid on the ties.

The two rails must be held together by a device as stiff vertically and laterally as the rail. This device should also have the same flexibility as the rail, should contain the least possible amount of material and the least number of parts. It should not touch the ties; but should allow the rail base or the tie-plates to afford the same bearing on the joint ties as on other ties. Spiking should be the same at the joint ties as elsewhere; except that it may be done in slots to prevent the creeping of the rail. This additional anti-creeping function of the joint will hardly interfere with it as a splice, if the spiking and bearing surfaces are otherwise kept the same at the splice as along the rail. Excessive or different spiking at the joints to compensate for a weak splice laterally makes rigid spots in the track and causes increased lateral wear at the rail ends. The splice must also hold the rails tight enough to give perfect safety and equal stiffness, and yet it must allow for expansion and contraction of the rails.

There are in addition to the requirements just mentioned, certain other difficulties imposed by natural and unavoidable limitations. The space around the rail ends is limited, and ideal conditions would not allow additions below the rail base on account of interfering with the ties and altering the bearing on them. This means that, if additions below the rail base must be used to get sufficient vertical stiffness, all such additions must be located between the ties; this, at the expense of having to adjust the ties somewhat, in order to clear the depending portions. Such adjustment, however, should not be a hardship, as the spiking facilities to prevent creeping are afforded at the same time.

It is now left to consider what appliances are available for meeting these requirements and limitations. This means, primarily, a criticism of the different types of rail joints, the best of which, necessarily, reduce the uniformity of the rail, from the fact that they are added parts; but the nearest approach to the ideal conditions is a splice bar rolled by several of the large steel companies. This bar has a stiffening flange to extend below the rail base between the ties, its end portions being cut away to clear the ties. This method of reinforcing the ordinary angle bar is as simple as it is effective, and it allows the use of the many good features of the angle bar which has stood the test for years. One of the best of these features preserved is, that the bars fit the rail only on two surfaces, which insures flexible adjustment and good tight-fitting contacts at all times, and in this they do not depend on any unusually accurate work at the rolling mills. It is obvious that a free depending flange can be designed and shaped so as to make the stiffness and flexibility of a pair of bars the same as a rail of any section, and also that the ordinary angle bar joint one-third as stiff as the rail can thus be transformed into one having the same stiffness as the rail. This reinforced type of bar is now standard on a number of the large eastern roads, and its popularity is rapidly extending to the various sections of the country where the heavy loads and increasing speeds are demanding stronger track.

There are several other designs of depending flange joints on the market, each with somewhat different characteristics. There is a tendency to make some of them of a light section and to rely on a shallow depending flange for stiffness. This, of course, is done in competition in order to produce a cheap bar. While these light bars give better service than the common angle bar, yet it is very evident that a certain amount of metal is required to make even these reinforced bars as strong as the rail.

Other types of joints not having depending flanges are numerous. Some can be made as strong as the rail, but in doing so too much metal is used, or the metal is so located that various irregularities are introduced, which counteract all the good effect of having a joint of the same strength and elasticity as the rail. Excessive stiffness, laterally or vertically, is just as bad as excessive weakness.

There have been some attempts to increase the stiffness of the common angle bar, and also other weak types, by making them of comparatively high carbon steel; but this has proven to be a great mistake, as the percentage of increase in stiffness is slight and the bars are more brittle and dangerous. The false economy of such a method is recognized when one considers that this practice simply means that the rail ends become worn in the fitting angles, instead of allowing the wear to be taken by the splice bars, which can be renewed at slight cost compared to the cost of the rail. After these fitting angles of the rail become worn by the hard bars, the rails ends cannot again be brought up to line and surface by renewing the splices. They are permanently damaged

and the result is further battering and ultimate renewal. The splice bars should always be of softer steel than the rail.

The increasing use of the different types of reinforced depending bars is a great step in advance. It clearly indicates the practical application of the line of thought here presented, and it may not be long until there will be a general acceptance of the uniform rail structure idea. This will mean improvement in design of the present appliances, as well as the production of new devices to meet more clearly defined requirements. But in it all, the one thing to be considered is, this fundamental idea of tying together the jointed rail structure, so that it will receive uniform wear throughout, as well as act on the ties and ballast with a uniform effect, and be as nearly as possible the same as a continuous rail. It is the failure of the most of the present rail structure to do this that not only makes trouble for the ties and ballast, but also causes battering and breaking of the rails and joints themselves. The railroad tracks must then be considered as made up of these three separate distributors: rails, ties and ballast, each, separately, to be made uniform throughout, one not requiring another to do part of its own work. This seems to be the correct principle to follow in meeting the demands for stronger and safer track. A little energy and thought thus rightly directed would go a long way toward saving some tremendous maintenance costs and, on many roads, would partly solve the problem as to whether or not train speeds must be reduced.

On April 4 the New York Central made tests on the line from Melrose north to Woodlawn to determine if possible, by actual trial, the speed the Brewster express was making when derailed on the Bedford Park curve on February 16, and also to find the maximum speed which a similar train could make on this stretch of track. Conditions were duplicated as far as possible, the test train consisting of two electric locomotives drawing five passenger cars weighted with sand bags to take the place of the passengers which the wrecked train had carried; the contact shoes on the right-hand side of one locomotive and on the left-hand side of the other were removed. The motorman ran the train according to directions given him by the motorman who had run the train when it was derailed. Two trips were made. On the first one the train reached a speed of 62.5 miles an hour at 183d street; at this point the controller, which had been at series-parallel with all resistance cut out, was brought down to series with all resistance cut out, as had been done at the time of the derailment. At Fordham, two-fifths of a mile farther, the controller was put back to series-parallel without resistance and the train rounded the curve a mile farther on at 48.9 miles an hour. The rails on the curve had been double spiked since the accident. The motorman of the wrecked train and several officials of the railroad testified before the New York State Railroad Commission that at the time of the derailment the train was running between 45 and 50 miles an hour. A number of passengers testified that, to the best of their knowledge, the speed was between 70 and 90 miles an hour at this point. The second test run was made to find the highest speed the train could make on straight track and at the curve. The line from Morrisania north to Fordham, 2.22 miles, is nearly straight, on an ascending grade of about 10 ft. to the mile. Over this stretch the motors were run wide open; that is, with the motors connected in parallel and all resistance cut out. The highest speed, 66.5 miles an hour, was made just south of Fordham. At Fordham the power was shut off while the train ran over some frogs and switch points, and five seconds later the controller was put at series-parallel without resistance, where it stayed until the curve was passed. The speed around the curve was 56.5 miles an hour. The locomotives took the curve without shock and with only a slight rocking. The distance from Melrose to Woodlawn is 5.68 miles. The schedule of the Brewster express at the time of the derailment in February made the time between these points seven minutes. The time for this distance on the first test last week, which was meant to duplicate the run of the train on the night of the derailment, was 6 min. 31 sec.; on the second test the distance was covered in 5 min. 48 sec. The following estimates of the speed of the New York Central electric locomotives were made about a month ago. It is to be noticed that these figures are not intended to show actual results, but merely the maximum speed at which the motors can revolve when connected up on the systems indicated. Between Melrose and 183d street the current is delivered to the locomotives at 600 volts; between 183d street and Fordham at 625 volts; and between Fordham and Williamsbridge at 650 volts.

Possible Maximum Speed, Running Light on Level Tangent Track in Still Air, with 600 Volts at Motors.

Position of controller.	Speed in miles per hour: One locomotive.	Two locomotives.
Controller in full series notch.............	28	30
Controller in full series-parallel notch.......	50	52
Controller in full parallel notch	86	90

CONTRIBUTIONS

The Profitable Weight and Speed of Freight Trains.

TO THE EDITOR OF THE RAILROAD GAZETTE:

I am pleased to see by the proof of Mr. Wild's article, which you were good enough to forward me, that the trend of opinion in railroad circles is beginning to swing away from the large train. From long practical experience under varying conditions, I have found that it is not economical to load engines down to their limit. In Canada, and I take it that it is the same in the United States, it is becoming more difficult all the time to attract the right type of men to the train service, and I attribute a great deal of this to the conditions governing in that service.

Many years ago I started out on the principle that the greatest economy was to be effected through loading engines to the limit, and like many of my confreres I overdid it. Finally I had to switch and found that more economy resulted from loading the trains so that they could get over the road in a reasonable time. Our engine districts here are approximately 130 miles. When we get our trains over in from eight to twelve hours, varying according to the density of the traffic, we have no trouble in keeping men, maintaining high efficiency and minimizing train accidents. Where it takes men from 18 to 24 hours to get a freight train over a 130-mile district, there is an excessive use of fuel and oil, engine failures become more frequent through bad firing as a result of the fireman's endurance being overtaxed, train and enginemen become logy and sleep in side tracks, and accidents result.

Apart from this phase of the question, the damage and wear and tear to rolling stock through overloading engines is tremendous, to say nothing of the damage to the contents of cars by the shocks consequent upon pulling out drawbars, resulting in the brakes going into emergency. In the territory that I have charge of, trains are loaded so that they can get over the road in good time. We use small eight-wheel engines on way freight trains, and principally very heavy 10-wheelers on our drags.

In my opinion the overloading of engines and strict adherence to seniority has done more than anything I can think of to prevent the most desirable type of men joining and remaining in the train service.

G. J. BURY,
General Superintendent, Canadian Pacific Railway.

Baltimore, Md., April 8, 1907.

TO THE EDITOR OF THE RAILROAD GAZETTE:

It was gratifying to note in your issue of March 8 that Mr. C. F. Noyes was able to confirm my table of load reductions for given increases of speed after making due allowance for terminal delays to engines. Mr. Noyes approaches the subject, however, very cautiously and does not venture to offer an opinion on net revenue results. I quote him as follows: "As to whether the net revenue accruing from the train hauled would show figures corresponding to results shown in number of hours that a given number of cars could be removed, or not, I am not prepared to say."

It is hoped that a perusal of this letter will assist him to a conclusion on the net revenue aspect of the case.

I will now deal with the letter of Mr. W. A. Worthington in your issue of March 29. I hope Mr. Worthington will not consider me unduly severe if I venture the opinion that he has completely begged the point at issue, and in doing so that he has given a most apposite illustration of the remark to be found in Mr. Noyes's letter that "As a rule it would seem that most operating officers base their loading and movement of trains on the showing a single train can make between any two terminals."

It is clearly obvious from my table that, granted the premises, a speed of 15 miles per hour accumulates more net revenue than a speed of 10 miles per hour within a given space of time, and this without an inch of additional track or another locomotive or car. In answer to this Mr. Worthington eliminates the element of time absolutely and fixing his mind purely on the motion element asks for more cars, locomotives and track room. He does not seem to see that the capital charge for his additional facilities would be an addition to the expense of operating at 10 miles an hour, so that his argument from the face of my table neglects an important item which if brought under consideration might actually knock the props from under his own reasoning.

The advocates of the big, slow moving train and the cheap ton-mile display, in my opinion, remarkable confusion of thought as to the connections between costs of operation and net revenues. What does it matter what is the cost of completing and paying for a period of railroad transportation provided the net revenue at the end of the period is more and provided that all the implements of operation have been maintained in proper working order. The operation of railroads is for the convenience of the public and for the accumulation of net revenue for those persons who have invested in them. The unavoidable conclusion from the reasoning of Mr. Worthington and gentlemen of his frame of mind—mostly graduates from the Jas. J. Hill school of thought—is that a rail-